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SOME PRELIMINARY DATA ON METHODS FOR ALLAYING COAL DUST IN TIPPLES AND CLEANING PLANTS

BY

D. S. KINGERY

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME PRELIMINARY DATA ON METHODS FOR ALLAYING COAL DUST IN TIPPLES AND CLEANING PLANTS[1]

By D. S. Kingery[2]

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1/ The Bureau of Mines will welcome reprinting of this paper, provided the following acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7248."

2/ Associate mining engineer, Safety Division, Bureau of Mines, Pittsburgh, Pa.

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INTRODUCTION

The control of coal dust on coal tipples and cleaning plants has not been given the consideration that is afforded underground dust hazards. This apparent oversight is undoubtedly due to the general opinion that coal-dust accumulation in tipples or cleaning plants does not present the same type of hazard that it does underground. That this opinion is at least in part a fallacy has been proved many times, and the Bureau of Mines has on record many examples of explosions in tipples and cleaning plants.3/

In addition to this explosion hazard, coal dust is considered by some authorities to be injurious to the health of individuals exposed to it.4/ Obviously, it reduces visibility and contributes materially to accident hazards and the discomfort of the employees. Several companies have recognized this dust hazard and the advantages derived from controlling it; consequently, they have installed equipment to allay and control the dust on their cleaning plants and tipples. The object of this paper is to summarize briefly some of the methods now in effect.

SIZES OF COAL DUST

The term "coal dust" as referred to in this paper means that portion of particulate matter which will pass through a 20-mesh screen. This definition is used by the Bureau of Mines and is based on the fact that dust particles coarser than 20-mesh ordinarily have little influence on the development of an explosion. Coal dust, therefore, is comprised of dust particles, all minus 20-mesh from the coarser to the finer sizes, averaging less than 1/2 micron, that is, less than 1/50,800 inch. These finer sizes, which are measured in microns, are the most detrimental from a health standpoint and the most difficult to suppress.5/

CLASSIFICATION OF COAL DUST

The sources of coal dust may be properly classified as primary or secondary. A primary source is one associated with appreciable degradation of size, that is, where the greater proportion of coal-dust particles is produced.

3/ Fene, W. J., and Owings, C. W., Explosions of Coal Dust in Tipples and Cleaning Plants and Some Suggestions on Preventing Them: Bureau of Mines Inf. Circ. 6895, 1936, 9 pp.

4/ Brundage, Dean K., and Frasier, Elizabeth S., The Health of Workers in Dusty Trades. Part III. Exposure to Dust in Coal Mining: U. S. Public Health Service Bull. 208, 1933, 13 pp.

5/ Owings, C. W., Method of Allaying Dust in Underground Mining Operations: Bureau of Mines Rept. of Investigations 3631, 1942, 38 pp.

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A secondary source may be considered as one in which most of the fines have been produced at some previous operation and are in such condition that they can be dispersed easily as air-borne dust. This paper deals principally with the suppression of secondary dust particles at tipples and cleaning plants. These may be considered to include dumping of coal-mine cars and skips, discharging coal from one conveyor to another, and loading railroad cars. The primary source to be studied is coal-breaking and crushing units.

EFFECT OF PRIMARY-DUST CONTROLS IN SECONDARY SUSPENSION

The coal-mining industry has made considerable progress during the past few years in controlling primary dust at its source by installing sprinkling systems on cutting and loading machines, sprays used at conveyor-discharge points, and sprinkling working places during drilling and before and after blasting.6/

It is reasonable to suppose that if the above primary-dust-suppression methods have fixed or "bound" the dust-forming fines they will not be dispersed at the secondary suspension source, or they would be greatly reduced. This was proved by D. H. Davis and G. R. Gardner in their tests on dust suppression in the Pittsburgh bed.7/

Accurate tests were made to determine the effect of suppression of dust at the primary sources of undercutting and drilling on the secondary dust sources of conveyor-discharge points and loading heads. It was found that the actual dust count was reduced 56 percent at the secondary source.

This fact indicates that the suspension of fine coal dust at such secondary sources as tipple and cleaning plants can be reduced materially by adequate methods of allaying dust during the underground mining methods; moreover, the dust hazard at dumping and loading points outside the mine is lessened. However, the constant degradation of coal in transit and the drying out of the treated coal in many cases necessitates additional treatment at the dumping points.

EXHAUST SYSTEMS OF DUST REDUCTION

Several mining companies have attacked the dust hazard by the expedient of removing the suspended dust by blowers and exhausting the dust

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6/ See footnote 5.

7/ Davis, D. H., and Gardner, G. R., An Investigation of Dust Suppression in the Pittsburgh Seam: Paper presented at New York meeting, Am. Inst. Min. and Met. Eng., February 1942.

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into a cyclone dust collector; this method encloses the entire dump or transfer point by hanging check curtains at the ends of the dump or coal-transit points, confining the dust and limiting the area of opening through which air might enter. The enclosures or hoods are attached to the main vacuum duct, which is usually of medium-gage steel 20 to 30 inches in diameter, connected to the dust collector. The pressure duct from the dust collector to the blower is generally the same size. A dedusting system of this type is based upon the following principle: Air is passed through the coal stream at relatively high velocity; this removes the finer particles of coal dust and carries them in suspension to the cyclone dust collector where, by reason of rapid expansion of the air duct, the velocity is decreased, and most of the dust particles settle out. The air then continues through the pressure duct to the blower and is exhausted.

This system, or a similar system of dust collecting where the dust-laden air passes through the fan before reaching the collecting unit, is in operation at several tipples or cleaning plants with varied success. One rotary dump, installed on the shaft bottom, completely enclosed, and utilizing an exhaust system similar to that described, was able to collect 125 pounds of coal dust for each 1,000 tons of coal dumped.8/

Many operators use vacuum-cleaning systems for removing accumulated dust from tipples. These systems, generally portable units although stationary ones are available which are excellent for this type of work, usually comprise a centrifugal exhauster, a dust collector, and one or more hoses for reaching and collecting the dust. These units are used only for collecting accumulated dust and are not to be confused with the dust-collecting system specifically designed to control the dust at its various sources.

NOZZLES USED ON SPRINKLING SYSTEMS

Spray nozzles are available in a number of styles, shapes, and sizes, which are adapted to special conditions and uses. The nozzles discussed in this paper are the most common types used for allaying dust in mines. They are hollow-cone-misting, hollow-cone-spray, full-solid-cone-spray, and standard-spray nozzles with interchangeable, various-size orifices.

1. The hollow-cone-misting nozzle delivers a fine mist and is usually installed where it is desirable to trap very fine dust particles in suspension and where larger volumes of solution would be undesirable. This type of spray has a rate-of-delivery curve as demonstrated in figure 1, A.

8/ Coal Age, Dust from Dump at Slope Bottom Removed by Vacuum at Tipple: Vol. 41, March 1936, pp. 111, 112.

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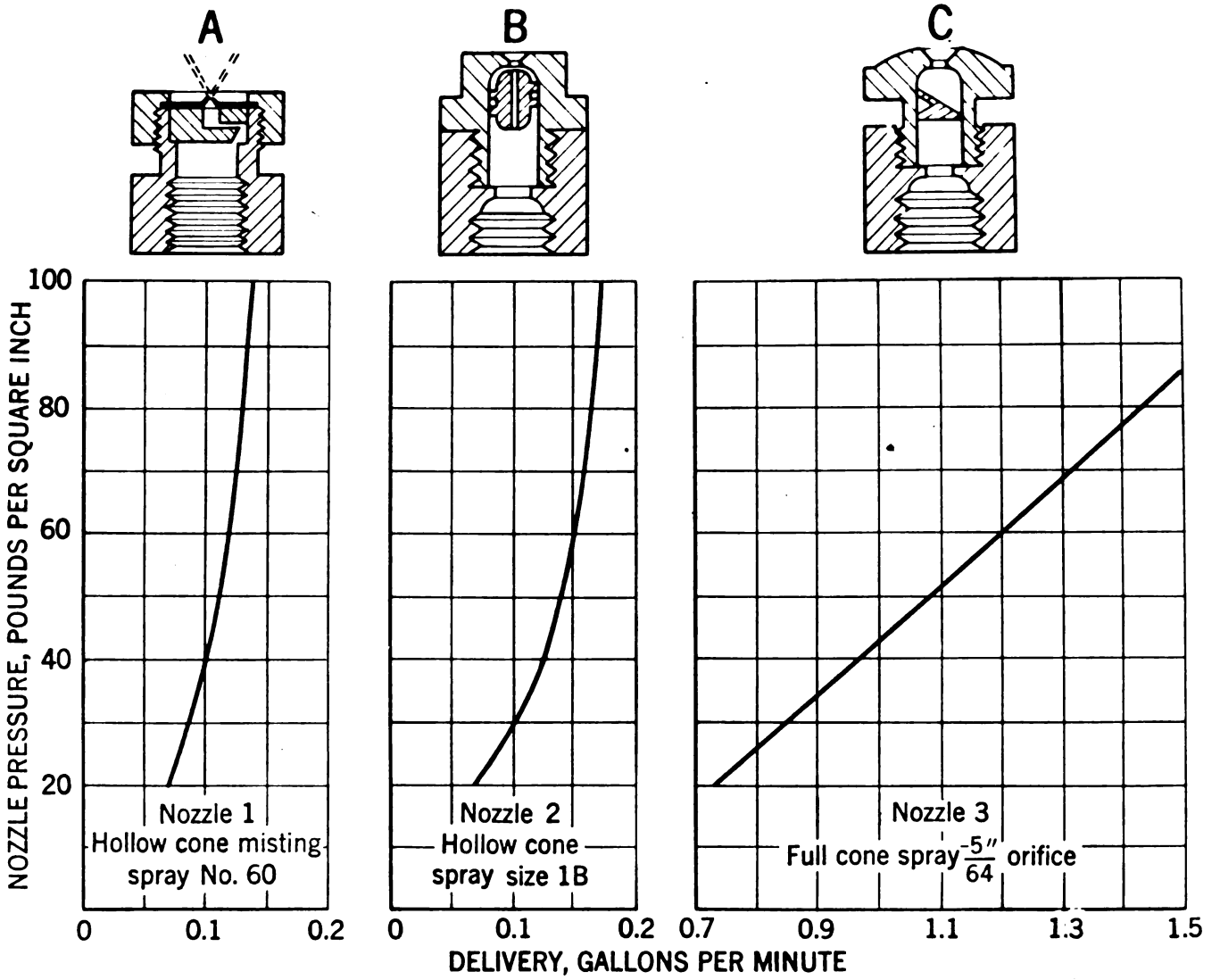

Figure 1, A, B, C.—Rate-of-delivery curves for spray nozzles.

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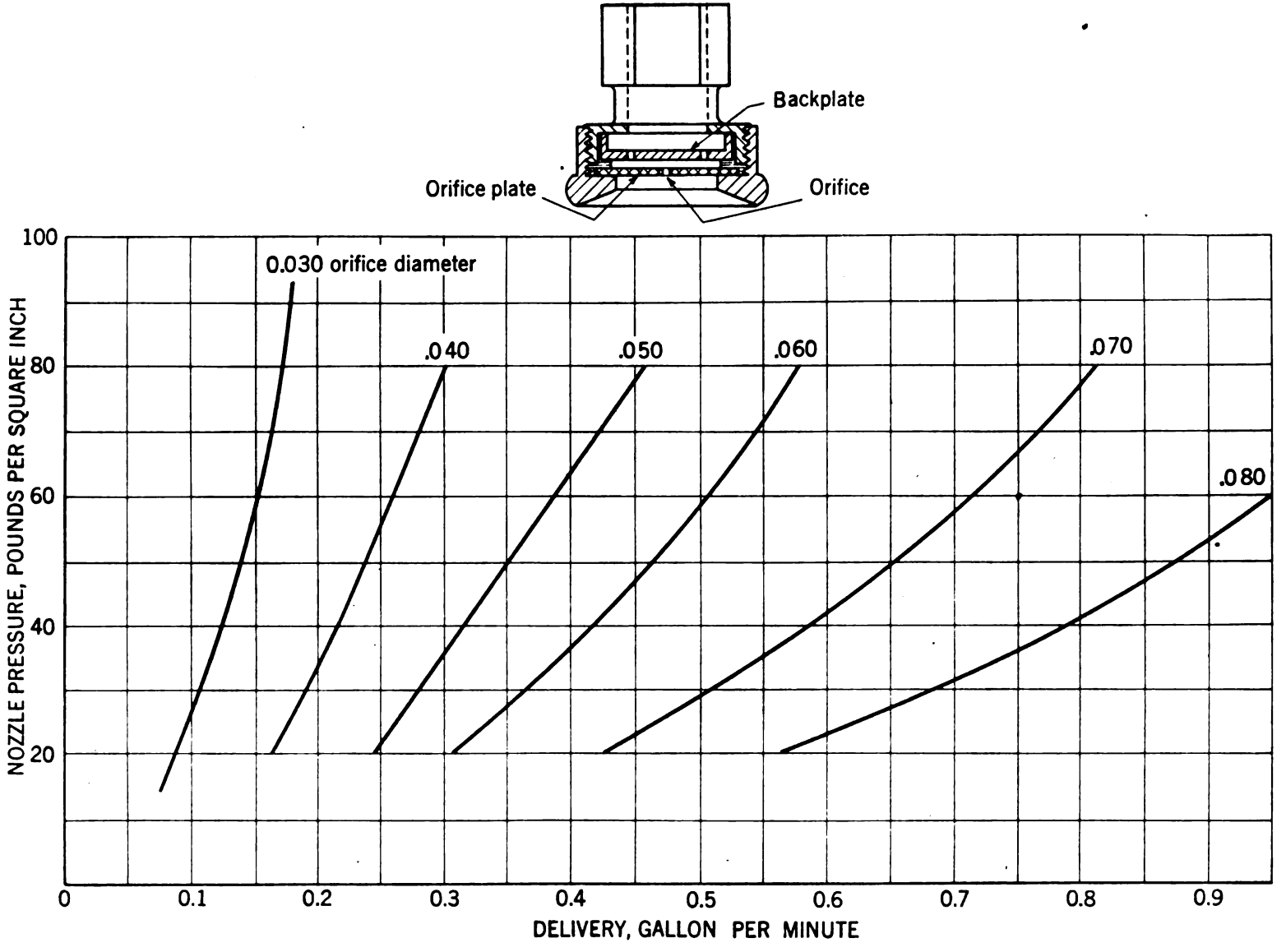

Figure 2.—Rate-of-delivery curves for spray nozzles.

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2. The hollow-cone-spray nozzle delivers a hollow spray and is usually installed for wetting dust in suspension at conveyor-discharge, loading, and transfer points, where the full-cone type of nozzle is not needed. The rate-of-delivery curve for this type of spray is shown in figure 1, B.

3. The full-solid-cone spray is the type most commonly used for wetting dust at mine-car dumps or coal-crushing units. It can also be used to trap suspended coal dust at conveyor-discharge and car-loading points. Figure 1, C, gives the rate-of-delivery curve for this type of spray.

4. The standard, interchangeable-orifice spray nozzle is a handy all-service type nozzle that can be used to replace either the hollow-or full-cone spray. The rate-of-delivery curve for this type nozzle showing the delivery for different-size orifices is given in figure 2.

WETTING AGENTS

Dust must be reduced without adding any excessive moisture to the coal, since consideration must often be given to the following:

1. Quality standards regarding reduction in heat value.

2. The handling characteristics, particularly in unloading from trucks or bins during the cold weather.

3. The application of dry methods of coal cleaning.

4. The necessity for screening the product within specified limits of size.

This can be accomplished by either the selection of fine-spray nozzles or the addition of a wetting agent to the water, thereby reducing the quantity of water needed.

This paper does not discuss the properties of wetting agents other than to cite the results of tests made by D. H. Davis and G. R. Gardner during their investigation of dust suppression in the Pittsburgh bed.[9/] They found that, when using a spray pressure of 35 pounds per square inch, a nozzle orifice of 0.040 inch, and spray water totaling 0.2 gallon per minute, several different wetting agents reacted as follows:

9/ See footnote 7.

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Reagent	Reagent concentration, percent	Reagent cost per 100 gallons of spray liquid	Reduction in dust, percent
Water			26
Wetting agent "A"	0.17	$ 0.21	54
Wetting agent "B"	.20	.21	60
Wetting agent "C"	.10	.30	71
Emulsion-forming oil	.40	.21	77
Do	.20	.125	60

The above table shows the effect of several wetting agents, giving a comparison of their costs. From this table it can be seen that the least effective wetting agent, which was "A", accomplished a dust reduction twice the effect of plain water. Distributors of wetting agents claim that their use will eliminate up to 70 percent of the water necessary to accomplish comparable results. This table indicates that the least effective wetting agent could have reduced the water by over 50 percent and that the most effective agent, which was an emulsion-forming oil, would have reduced the quantity of water needed by nearly 75 percent, thereby substantiating these claims for wetting agents.

METHOD OF WATER DISTRIBUTION

The problem of water distribution apparently is simple. There is often available pure city water at high pressures, or other water that can be placed in storage tanks or pumped directly into the spraying system. Water-supply lines are varied as to individual needs and are mostly 2- to 3-inch primary lines with 3/4-inch-diameter discharge lines to the sprays. The control of water is usually by means of hand-operated valves to curtain-type sprays placed over conveyor-discharge points or transfer points, and the water is seldom shut off. Other spray installations, especially those using wetting agents, are controlled by means of either solenoid valves or mechanical triggers to assure that the solution is not wasted or the coal wetted too much.

The danger of freezing water lines and spray systems during cold weather presents a problem, however, just at the time when the need for dust suppression is the greatest. Many of these sprinkling systems are either on the surface or on the bottom of downcast shafts on intake air. One company is preparing to place steam pipes parallel to the water lines to avoid this danger; another company is planning to use resistance cable, often called "greenhouse" cable, to prevent the pipes from freezing.

Either of these two methods can be made satisfactory. The steam-pipe method is the best if proper precautions are taken; however, steam is not always available. An alternate method is to heat the water before using it in the sprinkling system.

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SUPPRESSION OF SUSPENDED COAL DUST

The adequate control of dust in suspension requires overcoming several difficult physical factors. All of us have perceived the phenomenon of suspended dust particles in the air after a rain, or have observed in mines particles of coal dust floating on the surface of water pools or even rising from the bottom of the pool through the water to the top, remaining perfectly dry. This fact can be explained by the capillary absorption of air into the capillary spaces. The dust particle is extremely small, having relatively little mass or gravity; consequently, air will completely surround the dust particle, thus providing a protective sheath which makes it difficult for water to strike the coal particle and displace the air.

To overcome this phenomenon it is necessary to apply water of sufficient force or a wetting-agent solution to break the film around the dust particle and displace the air remaining within the capillary space. This is difficult to accomplish; consequently, sprays are placed to trap the suspended fine dust particles, thereby preventing further diffusion, and to wet the larger particles which, by their superior mass, will fall more readily and bring some of the finer particles with them. The adherence of many of the finer particles to the wetted particles makes it more difficult to throw them into suspension again. To aid in accomplishing this, the dust source should be covered by a hood or some other enclosure.

The location and the type of spray installation vary with each individual plant; however, a few factors should be considered:

1. In very dusty operations, where the coal passes along conveyors discharging onto a second conveyor or feeder, it may be advisable to place sprays beneath the coal-discharge stream, inasmuch as the finer coal particles will sift down to the bed of the conveyor during transportation and can be more effectively trapped at this point.

2. When installing spray systems, consideration should be given to the use of automatic control valves; otherwise, much water will be wasted needlessly, and the conveyors' beds wetted, causing the coal to clog and stick during screening.

3. Consideration should also be given to the "run-off" water on dump installations where considerable water may be used, or water may accumulate to the point where the conveyor equipment may be impaired.

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SOME DUST-SUPPRESSION METHODS NOW IN EFFECT AT VARIOUS OPERATIONS

Figure 3 shows the installation of a sprinkling system on a two-car rotary dump. This is located at the bottom of a return shaft, therefore no provision has been made for heating the system during cold weather.

The company utilizing this spray has a twofold purpose in doing so: In addition to its need for suppressing coal dust, it is desirous of adding approximately 1 percent of moisture to its coal. The coal is screened at a tipple on the surface and then burned at its own power plant nearby. This installation, which has been in service for 4 years, uses city water. Approximately 17 gallons of water is sprayed at each turn of the dump on approximately 7 tons of coal. This is the equivalent of 2.4 gallons of water per ton, and if all the moisture is retained by the coal this increases the moisture content by 1 percent which is the desired increase.

The mechanical principle of this installation is as follows: The dump revolves clockwise, causing the lower catch to move into place and engage the lower trigger placed on the left side of the dump. This trigger is thrown upward, and at the same time, by means of mechanical connections, the upper trigger is moved down; this opens the pilot valve controlling the flow of water. During the interval, in which the dump moves approximately 60 degrees and until the upper right-hand catch moves to engage the upper trigger, the water spray is turned on. When the upper trigger is moved back, the pilot valve closes, and the water supply is cut off.

The water supply is maintained in a pressure tank under compressed air which provides the pressure for the water stream when the pilot valve is opened. The type of nozzle used for this system is not described in this paper but is illustrated in the figure. It is a high-pressure nozzle, capable of spraying 2 gallons of water per minute. Nine such nozzles, placed in the positions indicated on the figure, wet the coal thoroughly as it is dumped into the hoisting skip.

No dust counts were taken to determine the efficiency of this operation; however, from personal observation, it was noted that very little dust was in suspension, and practically no dust accumulations were on the floor or on the ledges in the vicinity of this dumping station. The company officials stated that the addition of this quantity of water had not affected the screening properties of the coal; however, not many fine sizes are required for commercial use.

Figure 4 shows the installation of a sprinkling system on a single-car rotary dump at a shaft bottom. This installation uses a chemical wetting agent

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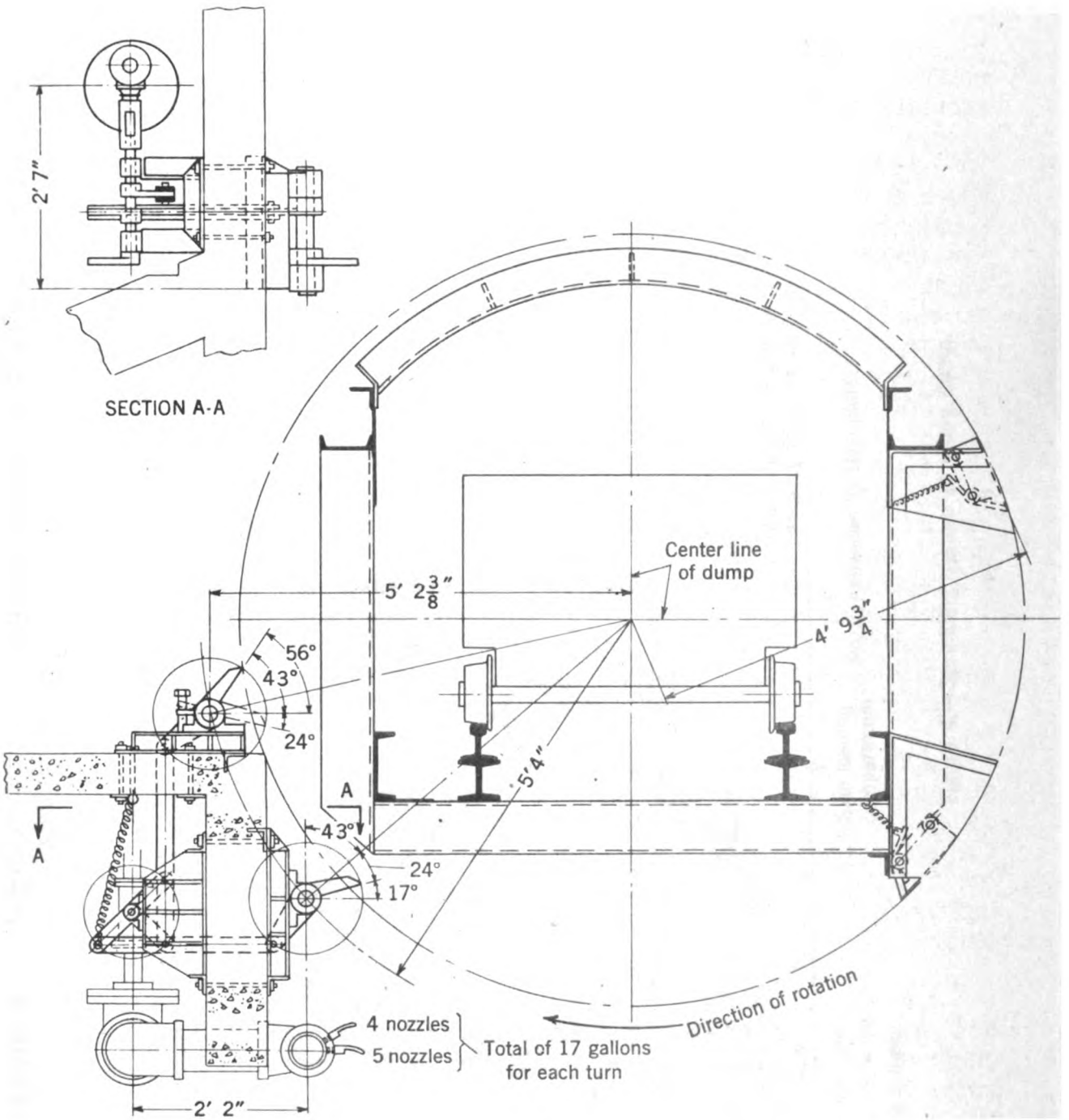

Figure 3.—Sprinkling system for allaying dust at rotary dump.

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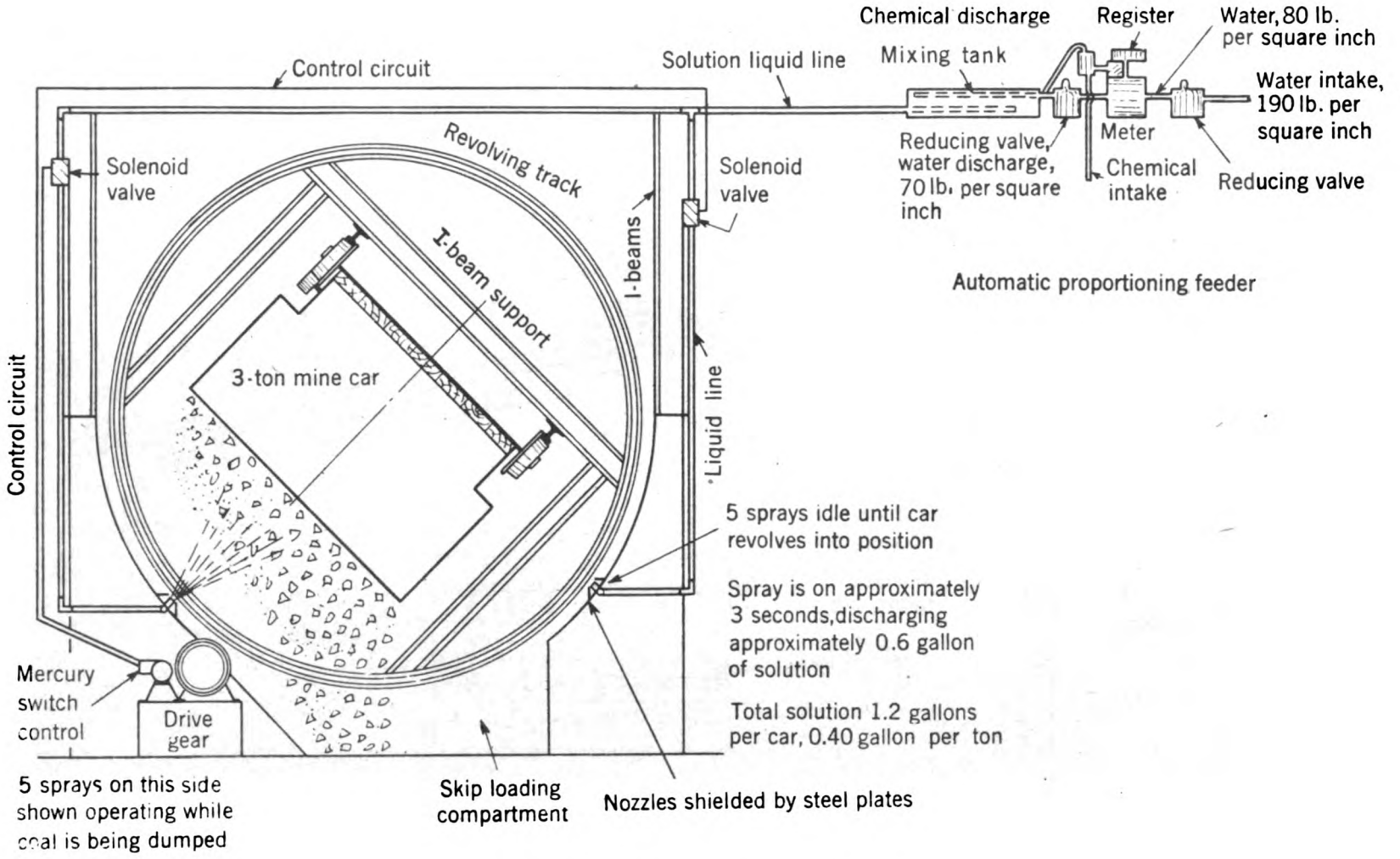
Chemical discharge
Register
Water, 80 lb. per square inch
Mixing tank
Solution liquid line
Control circuit
Water intake, 190 lb. per square inch
Meter
Reducing valve, water discharge, 70 lb. per square inch
Chemical intake
Reducing valve
Automatic proportioning feeder
Revolving track
Solenoid valve
Solenoid valve
I-beams
T-beam support
3-ton mine car
Control circuit
Liquid line
5 sprays idle until car revolves into position
Spray is on approximately 3 seconds, discharging approximately 0.6 gallon of solution
Total solution 1.2 gallons per car, 0.40 gallon per ton
Mercury switch control
Drive gear
5 sprays on this side shown operating while coal is being dumped
Skip loading compartment
Nozzles shielded by steel plates

Figure 4.—Sprinkling system at rotary dump.

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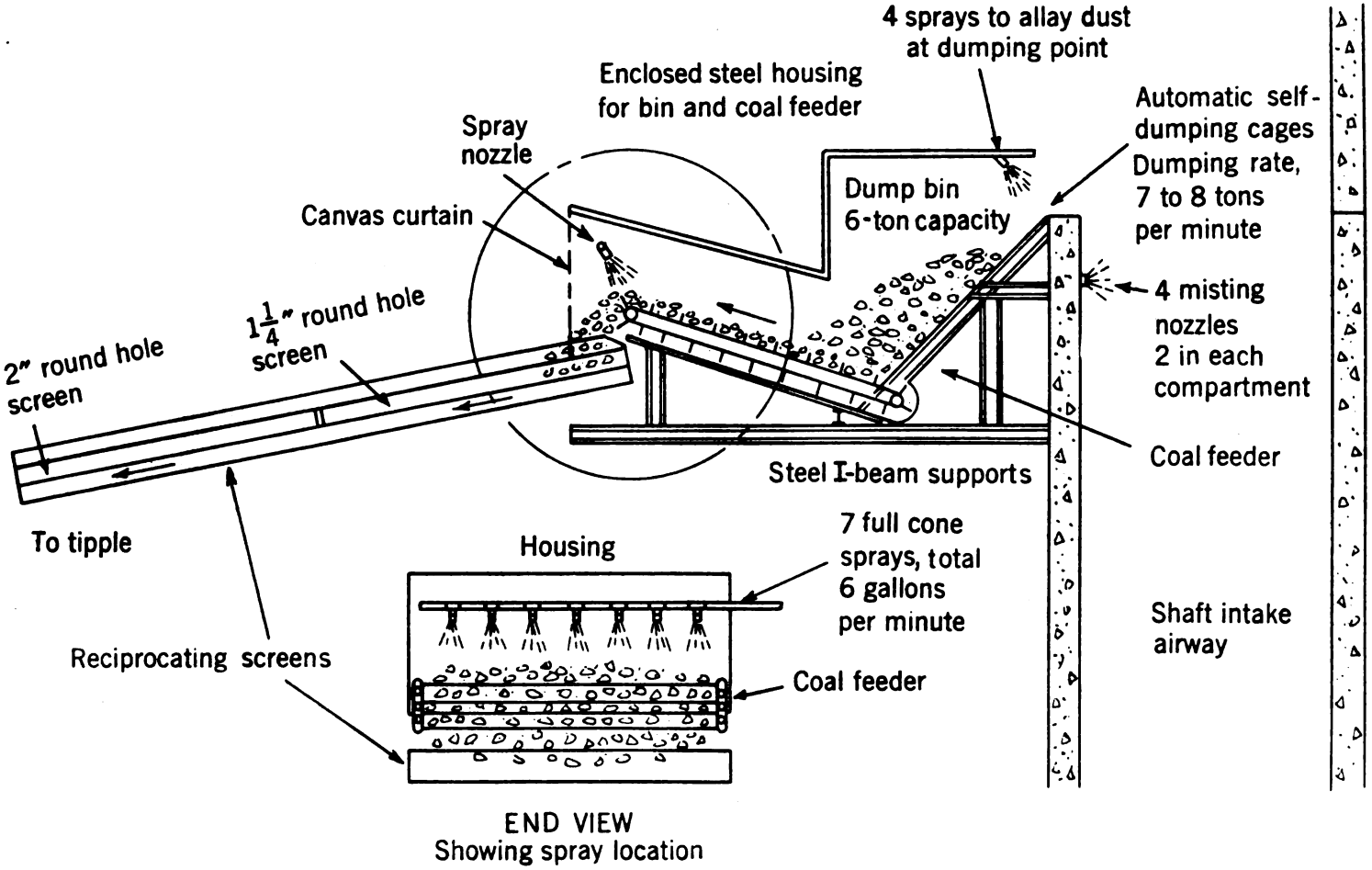
4 sprays to allay dust at dumping point
Enclosed steel housing for bin and coal feeder
Automatic self-dumping cages
Dumping rate, 7 to 8 tons per minute
Spray nozzle
Dump bin 6-ton capacity
Canvas curtain
4 misting nozzles 2 in each compartment
1¼" round hole screen
2" round hole screen
Coal feeder
Steel I-beam supports
To tipple
Housing
7 full cone sprays, total 6 gallons per minute
Shaft intake airway
Reciprocating screens
Coal feeder
END VIEW
Showing spray location

Figure 5.—Sprinkling system at coal-discharge points.

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mixed with city water to form a wetting solution. The mixing is done by an automatic proportioning feeder in the weigh house. City water at 190 pounds pressure flows through a reducing valve before entering the feeder, because it was found necessary to reduce the water pressure to 80 pounds to keep the unit from leaking. A chemical is drawn from the chemical-supply drum through a suction line to the register unit by a diaphragm pump; the register and the water meter are synchronized to give the desired solution proportions.

Operation of this sprinkling system requires the use of solenoid valves to control the flow of the solution. These valves are energized by means of mercury switches placed on a timing wheel, operated by the regular dump drive gear which revolves counterclockwise. As the dump turns, the timing wheel allows the mercury switch to close the circuit, the solenoid valve operates, and the spray is turned on. As the dump continues to revolve, the circuit is broken and the spray stops. This installation employs two sprays, one spray hitting the coal as it is being dumped and the other striking the empty car during the upturn, as shown on the sketch.

The amount of solution used during this entire operation is approximately 0.75 gallon. The spray nozzles are of the full-cone type, capable of discharging 1.5 gallons of solution per minute. The sprays are in operation for approximately 3 seconds, furnishing the equivalent of 0.25 gallon of solution to the ton of coal dumped.

This system is quite effective, and very little dust can be seen in suspension surrounding the dumping station. The company operating this system is also using sprays on cutting machines within the mine; consequently, the amount of dust diffusion is not as great as would be expected from coal that had not been pretreated.

Figure 5 shows a sprinkling system installed to suppress the dust from automatic self-dumping, 3-ton cages at the top of an intake air shaft.

The coal is dumped from both shaft compartments at a total dumping rate of 7 to 8 tons per minute. The cars are dumped by the cages into the receiving bin, which has a 6-ton capacity and feeds the coal by gravity into the coal-feeder conveyor. This conveyor discharges the coal to the reciprocating shaker screens. The entire receiving-bin assembly is enclosed by sheet steel, with a canvas curtain hung at the coal-discharge point.

Fifteen sprays are used to control the dust at this location. Four misting spray nozzles are placed in the shaft wall to prevent fine dust from being drawn down the shaft by the ventilating currents; four full-cone-type sprays are located above the dumping point to trap dust and prevent it from escaping

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from the enclosure; and, at the discharge point where the feeder-conveyor dumps onto the reciprocating screen, there is a row of seven full-cone sprays. These 15 spray nozzles deliver approximately 10 gallons of water per minute, 8 gallons of which is added to the coal (2 gallons being used by the misting-sprays in the shaft), indicating the addition of approximately 1 gallon of water per ton of coal.

This installation uses city water at a pressure of 115 pounds per square inch for the wetting medium. The sprays are hand-operated by valves and normally run throughout the dumping shift. There is no preparation at present to keep the water lines from freezing; it is understood, however, that the company plans to place steam pipes parallel to the water lines to prevent freezing during cold weather.

The effectiveness of the dust-suppression system was tested by placing an enameled disk on the floor of the tipple at a dusty point and allowing dust to accumulate on it for 1 minute with the sprays off. The dust-covered disk was accurately weighed, and the disk was then cleaned off and reweighed. The same test was then made with the sprinkling system in operation. When the results were compared, it was found that sprinkling reduced the amount of dust collected on the disk by over 99 percent.

Figure 6 shows a dust-reduction system which is simply a series of sprays installed under the weigh pan of a break-over dump. Coal is dumped from the car into the weigh pan and weighed. The discharge fly is then turned and the coal is discharged into the receiving chute. Here it feeds by gravity onto the coal-feeder conveyor, which is partly enclosed. From this feeder-conveyor, the coal is discharged onto a belt-conveyor which moves the coal to the tipple.

The effectiveness of this dedusting system is limited because the coal is weighed in the weigh pan, and any sprays placed to check the dust at the dumping point interfere with the scale weight. With a different method of weighing coal, satisfactory placement of sprays could be arranged which would check the dust at the dumping point as well as at other dust sources.

The spray nozzles for this system are placed where they will spray the coal as it is discharged from the weigh pan into the enclosed coal chute and also at the discharge point of the main coal-feeder conveyor. The 6 spray nozzles at the discharge point deliver approximately 4 gallons of water per minute. The two sprays at the discharge point of the feeder-conveyor deliver approximately 1 gallon of water per minute. This makes a total of approximately 5 gallons of water per minute, or less than 1 gallon of water to each ton of coal.

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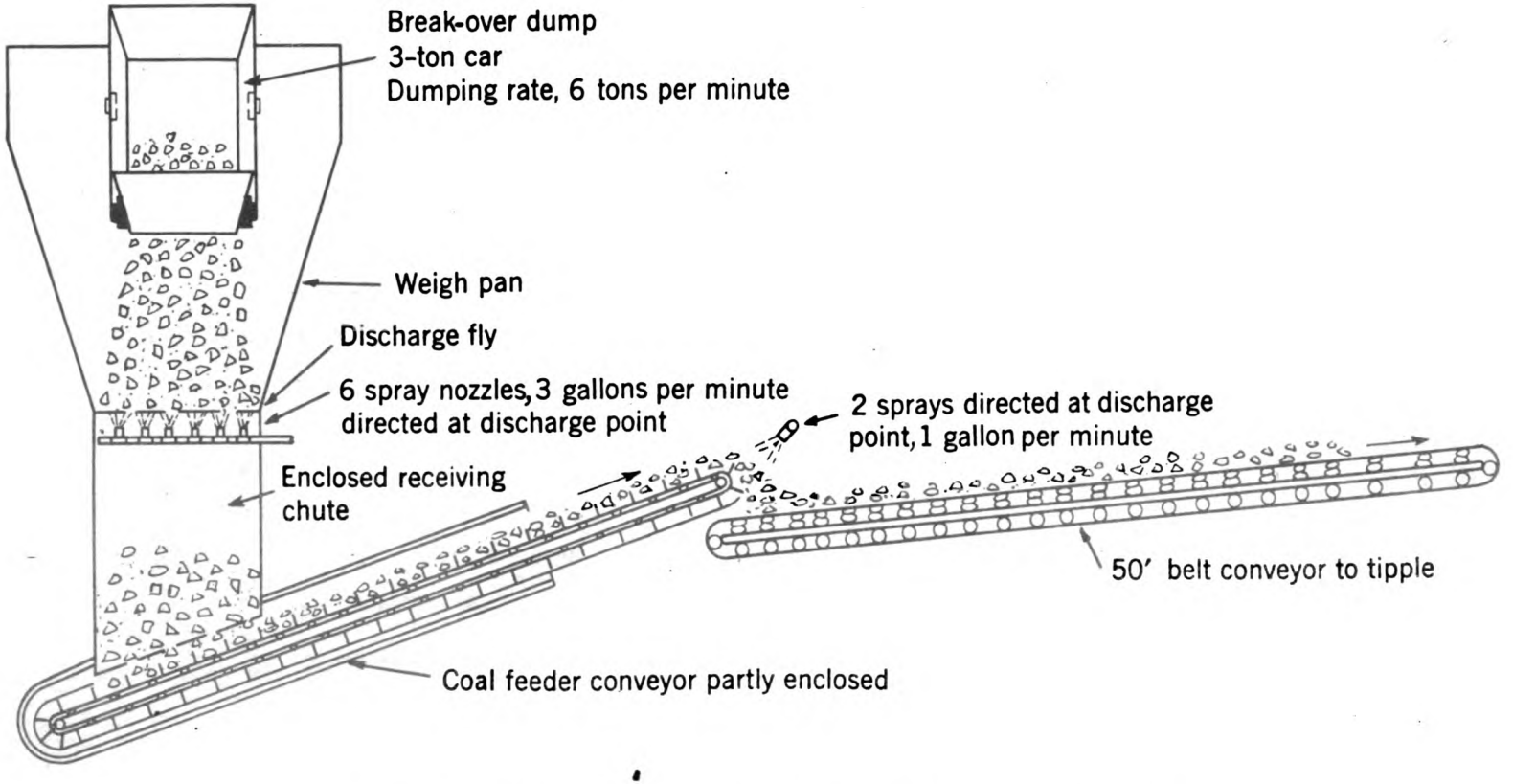

Figure 6.—Sprinkling system at discharge point of break-over dump.

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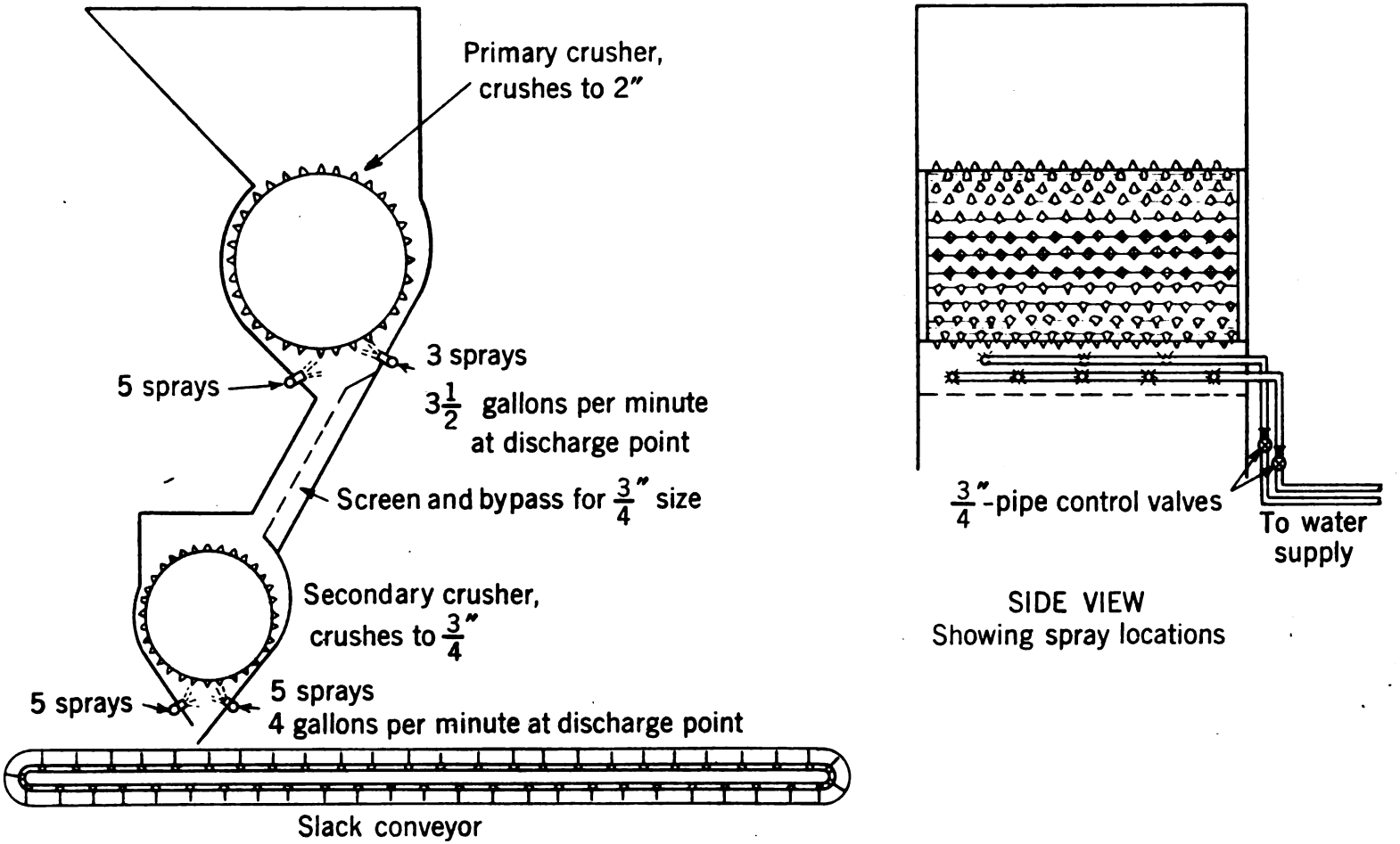

Figure 7.—Sprinkling system used on coal crushers.

Original from THE OHIO STATE UNIVERSITY

This system uses city water at 85 pounds pressure for the sprinkling system. The valves are hand-operated, and the sprinklers operate continuously throughout the dumping process. At present there is no method in operation to prevent water lines from freezing during cold weather; it is understood that the company employing this system plans to install a boiler to preheat the water used during the winter months.

Figure 7: The only primary-dust source usually found in tipples or cleaning plants is the coal-crushing unit. This unit, unless controlled, is a prolific source of dust. The sketch shows a simple arrangement whereby sprays can be installed to suppress the dust produced by this machine. The crushing unit is usually enclosed; therefore, a line of full-cone sprays from each side will prove very effective. One row of sprays should be higher and directed upward into the crushed coal being discharged. The other spray, on the opposite side of the crusher, should be lower and directed on a level to check the rising dust particles. This arrangement, or a similar one, could be installed in nearly any type of coal-crushing machine.

SUMMARY

This brief review of the problems and conditions involved in suppressing coal dust at tipples and cleaning plants and of the systems employed by various companies in solving them indicates that definite results can be accomplished. These systems in actual practice show that a large volume of water need not be used; 1 gallon per ton is sufficient, except in special cases, and this amount of water does not unduly hinder or handicap the screening of the treated coal into commercial sizes. A type of spray nozzle of almost any shape, size, and capacity is available for nearly any purpose that might be beneficial to the dust-suppression system. Wetting agents may be obtained that will reduce the amount of water needed to allay the dust, as well as special mechanical devices, such as the automatic proportional feeder to augment the effectiveness of the wetting agents.

The benefits that may be expected as a result of instituting a dust-suppression system in tipples and cleaning plants are the removal of the explosion and fire hazards from coal dust, better visibility and the resultant accident reduction, and more healthful working conditions for employees, together with improved employer-employee relationships.

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